What is claimed is:

1. A method for tuning a cost function used by a neural network control system configured to control an operational plant having a known plant phase response to each of a range of known signals, the neural network control system including a neural network model and a cost function, the method comprising:

selecting parameters used in a cost function;

selecting an input weight to be applied to a control output by the cost function;

selectively incorporating predicted future states generated by a neural network model;

iteratively applying a control input from a range of known signals;

calculating a control output in response to the control input;

determining a control system phase and a control system amplitude of the control output in response to the control input; and

combining a known plant phase with regards to a known signal equivalent to the control input and the control system phase such that effectiveness of the cost function parameters, the input weight, and the selectively incorporated predicted future states is determinable.

2. The method of Claim 1, wherein the input weight to be applied by the cost function is iteratively selected from among a range of input weights.

3. The method of Claim 2, wherein the range of input weights includes a maximum of around 0.001 to a minimum of around 01 x 10^{-20}.

4. The method of Claim 1, wherein selectively incorporating the predicted future states includes selecting a subset of the predicted future states generated by the neural network model.

5. The method of Claim 4, wherein selectively incorporating the predicted future states includes incorporating two of the predicted future states generated by the neural network model.

6. The method of Claim 1, wherein selectively incorporating the predicted future states includes incorporating all of the predicted future states and combining each of the predicted future states with a forget factor such that a proportional weight is accorded each of the predicted future states.

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7. The method of Claim 6, wherein the forget factor includes one of a whole and a fractional number raised to an exponent incremented by one for each of the predicted future states.

8. The method of Claim 7, wherein the forget factor is in a range from around 5.0 to around 0.1.

9. The method of Claim 8, further comprising sequencing the combining of the forget factors with the predicted future states such that each of the forget factors is applied to each of the predicted future states.

10. The method of Claim 1, wherein the range of known signals applied as the control input signal includes a chirp signal.

11. The method of Claim 1, wherein the cost function includes an expression:

$$C=\sum_{i=1}^{n}\left(G_p \bullet Y_i^2 + G_v \bullet \dot{Y}_i^2 + G_I \bullet I^2\right)$$

where:

C = cost of selected input (I);

i through n represent a range of the predicted future states being evaluated;

G_p = position gain;

Y_i = predicted state of the plant at horizon I;

$\dot{Y}_i$ = predicted rate of change of the state of the plant at horizon I;

G_v = velocity gain; and

G_I = the model input.

12. The method of Claim 11, wherein the cost function parameters selected is the position gain and the velocity gain.

13. The method of Claim 12, wherein the position gain selected includes one of 0 and 1 and the velocity gain selected includes one of 0 and 1.

14. The method of Claim 7, wherein the cost function includes an expression:

$$C=\sum_{i=1}^{n}\left(G_p \bullet Y_i^2 + G_v \bullet \dot{Y}_i^2 + G_I \bullet I^2\right)\bullet W^i$$

where:

C = cost of selected input (I);

i through n represent a range of the predicted future states being evaluated;

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G_p = position gain, Y_i = predicted state of the plant at horizon I;

$\dot{Y}_i$ = predicted rate of change of the state of the plant at horizon I;

G_v = Velocity Gain;

G_I = input gain; and

W = the forget factor.

15. The method of Claim 14, wherein the cost function parameters selected include the position gain and the velocity gain.

16. The method of Claim 15, wherein the position gain selected includes one of 0 and 1 and the velocity gain selected includes one of 0 and 1.

17. The method of Claim 1, wherein a combination of parameters and input weight resulting in three consecutive maximum control output values is dismissed as unstable.

18. The method of Claim 17, wherein iteratively applying the control input from the range of known signals ceases for the combination of parameters and input weight resulting in three consecutive maximum control output values dismissed as unstable.

19. The method of Claim 1, wherein the control system phase is determined by performing a fast Fourier transform of the control output in response to the control input signal and the known plant phase is determined by performing a fast Fourier transform of the plant phase in response to a plant input.

20. The method of Claim 19, wherein stable combinations of the cost function parameters, the input weight, and the predicted future states are indicated by a sum of the control system phase and the plant phase ranging between around +150 degrees though 180 degrees to −150 degrees inclusive.

21. The method of Claim 19, wherein more stable combinations of the cost function parameters, the input weight, and the predicted future states are those for which the sum of the control system phase and the plant phase is closest to around 180 degrees or around negative 180 degrees and less stable combinations of the cost function parameters, the input weight, and the predicted future states are those for which the sum of the control system phase and the plant phase is closest to around 0 degrees.

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22. The method of Claim 21, wherein the stable combinations of the cost function parameters, the input weight, and the predicted future states are ranked from the more effective combinations to the less effective combinations.

23. A method for tuning a cost function used by a neural network control system configured to control an operational plant having a known plant phase response to each of a range of known signals, the neural network control system including a neural network model and a cost function, the method comprising:

selecting parameters used in a cost function;

selecting an input weight to be applied to a control output signal by the cost function;

selectively incorporating predicted future states generated by a neural network model by incorporating at least two of the predicted future states generated by the neural network model;

iteratively applying a control input signal from a range of known signals;

calculating a control output in response to the control input signal;

determining a control system phase and a control system amplitude of the control output in response to the control input signal; and

combining a known plant phase with regards to a known signal equivalent to the control input signal and the control system phase such that effectiveness of the cost function parameters, the input weight, and the selectively incorporated predicted future states is determinable.

24. A method for tuning a cost function used by a neural network control system configured to control an operational plant having a known plant phase response to each of a range of known signals, the neural network control system including a neural network model and a cost function, the method comprising:

selecting parameters used in a cost function;

selecting a plant input weight to be applied to a control output signal by the cost function;

incorporating predicted future states generated by a neural network model by incorporating all of the predicted future states and combining each of the predicted future states with a forget factor such that a proportional weight is accorded each of the predicted future states;

iteratively applying a control input signal from a range of known signals;

calculating a control output in response to the control input signal;

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determining a control system phase and a control system amplitude of the control output in response to the control input signal; and

combining a known plant phase with regards to a known signal equivalent to the control input signal and the control system phase such that effectiveness of the cost function parameters, the input weight, and the selectively incorporated predicted future states is determinable.

25. A computer-readable medium for tuning a cost function used by a neural network control system configured to control an operational plant having a known plant phase responsive to each of a range of known signals, the neural network control system including a neural network model and a cost function, the computer-readable medium comprising:

first computer program code means for selecting parameters used in a cost function;

second computer program code means for selecting an input weight to be applied to a control output signal by the cost function;

third computer program code means for selectively incorporating predicted future states generated by a neural network model;

fourth computer program code means for iteratively applying a control input signal from a range of known signals;

fifth computer program code means for calculating a control output in response to the control input signal;

sixth computer program code means for determining a control system phase and a control system amplitude of the control output in response to the control input signal; and

seventh computer program code means for combining a known plant phase responsive to a known signal equivalent to the control input signal and the control system phase such that effectiveness of the cost function parameters, the input weight, and the selectively incorporated predicted future states is determinable.

26. The computer-readable medium of Claim 25, wherein the input weight to be applied by the cost function is iteratively selected by the second program code means from among a range of input weights.

27. The computer-readable medium of Claim 26, wherein the range of input weights includes a maximum of around 0.001 to a minimum of around 1×10^{-20}.

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28. The computer-readable medium of Claim 25, wherein selectively incorporating the predicted future states includes the third computer program code means selecting a subset of the predicted future states generated by the neural network model.

29. The computer-readable medium of Claim 28, wherein selectively incorporating the predicted future states includes the third computer program code means incorporating two of the predicted future states generated by the neural network model.

30. The computer-readable medium of Claim 25, wherein selectively incorporating the predicted future states includes the third computer program code means incorporating all of the predicted future states and combining each of the predicted future states with a forget factor such that a proportional weight is accorded each of the predicted future states.

31. The computer-readable medium of Claim 30, wherein the forget factor applied by the third computer program code means includes one of a whole number and a fractional number raised to an exponent incremented by one for each of the predicted future states.

32. The computer-readable medium of Claim 31, wherein the forget factor applied by the third computer program code means is in a range from around 5.0 to around 0.1.

33. The computer-readable medium of Claim 32, further comprising an eighth computer program code means for sequencing the forget factors with the predicted future states such that each of the forget factors is applied to each of the predicted future states.

34. The computer-readable medium of Claim 25, wherein the range of known signals applied by the fourth computer program code means as the control input signal includes a chirp signal.

35. The computer-readable medium of Claim 25, wherein the cost function includes an expression:

$$C = \sum_{i=1}^{n} \left(G_p \bullet Y_i^2 + G_v \bullet \dot{Y}_i^2 + G_I \bullet I^2 \right)$$

where:
C = cost of selected input (I);
i through n represent a range of the predicted future states being evaluated;
G_p = position gain;
Y_i = predicted state of the plant at horizon I;
$\dot{Y}_i$ = predicted rate of change of the state of the plant at horizon I;

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G_v = velocity gain; and
G_I = the model input.

36. The computer-readable medium of Claim 35, wherein the cost function parameters selected by the first computer program code means are the position gain and the velocity gain.

37. The computer-readable medium of Claim 36, wherein the position gain selected by the first computer program code means includes one of 0 and 1 and the velocity gain selected by the first computer program code means includes one of 0 and 1.

38. The computer-readable medium of Claim 31, wherein the cost function includes an expression:

$$C = \sum_{i=1}^{n} \left(G_p \bullet Y_i^2 + G_v \bullet \dot{Y}_i^2 + G_I \bullet I^2 \right) \bullet W^i$$

where:
C = cost of selected input (I);
i through n represent a range of the predicted future states being evaluated;
G_p = position gain, Y_i = predicted state of the plant at horizon I;
$\dot{Y}_i$ = predicted rate of change of the state of the plant at horizon I;
G_v = Velocity Gain;
G_I = input gain; and
W = the forget factor.

39. The computer-readable medium of Claim 38, wherein the cost function parameters selected by the first computer program code means include the position gain and the velocity gain.

40. The computer-readable medium of Claim 39, wherein the position gain selected by the first computer program code means includes one of 0 and 1 and the velocity gain selected by the first computer program code means includes one of 0 and 1.

41. The computer-readable medium of Claim 25, further comprising eighth computer program code means for dismissing as unstable a combination of parameters and input weight resulting in three consecutive maximum control output values.

42. The computer-readable medium of Claim 41, further comprising ninth computer program code means for ceasing iteratively applying the control input from the range of

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known signals ceases for the combination of parameters and input weight resulting in three consecutive maximum control output values dismissed as unstable.

43. The computer-readable medium of Claim 35, wherein the control system phase is determined by the sixth computer program code means by performing a fast Fourier transform of the control output in response to the control input signal and the known plant phase is determined by performing a fast Fourier transform of the plant phase in response to a plant input.

44. The computer-readable medium of Claim 43, further comprising a ninth computer program code means for identifying stable combinations of the cost function parameters, the input weight, and the predicted future states wherein the stable combinations are indicated by a sum of the control system phase and the plant phase ranging between around 150 degrees though 180 degrees to –150 degrees inclusive.

45. The computer-readable medium of Claim 43, wherein more stable combinations of the cost function parameters, the input weight, and the predicted future states are those for which the sum of the control system phase and the plant phase is closest to around 180 degrees or around negative 180 degrees and less stable combinations of the cost function parameters, the input weight, and the predicted future states are those for which the sum of the control system phase and the plant phase is closest to around 0 degrees.

46. The computer-readable medium of Claim 45, further comprising a tenth computer program code means for ranking the effective combinations of the cost function parameters, the input weight, and the predicted future states from the more effective combinations to the less effective combinations.

47. A computer-readable medium for tuning a cost function used by a neural network control system configured to control an operational plant having a known plant phase responsive to each of a range of known signals, the neural network control system including a neural network model and a cost function, the computer-readable medium comprising:

first computer program code means for selecting parameters used in a cost function;

second computer program code means for selecting an input weight to be applied to a control output signal by the cost function;

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third computer program code means for selectively incorporating predicted future states generated by a neural network model by incorporating at least two of the predicted future states generated by the neural network model;

fourth computer program code means for iteratively applying a control input signal from a range of known signals;

fifth computer program code means for calculating a control output in response to the control input signal;

sixth computer program code means for determining a control system phase and a control system amplitude of the control output in response to the control input signal; and

seventh computer program code means for combining a known plant phase with regards to a known signal equivalent to the control input signal and the control system phase such that effectiveness of the cost function parameters, the input weight, and the selectively incorporated predicted future states is determinable.

48. A computer-readable medium for tuning a cost function used by a neural network control system configured to control an operational plant having a known plant phase responsive to each of a range of known signals, the neural network control system including a neural network model and a cost function, the computer-readable medium comprising:

first computer program code means for selecting parameters used in a cost function;

second computer program code means for selecting an input weight to be applied to a control output signal by the cost function;

third computer program code means for incorporating predicted future states generated by a neural network model and combining each of the predicted future states with a forget factor such that a proportional weight is accorded each of the predicted future states;

fourth computer program code means for iteratively applying a control input signal from a range of known signals;

fifth computer program code means for calculating a control output in response to the control input signal;

sixth computer program code means for determining a control system phase of the control output in response to the control input signal; and

seventh computer program code means for combining a known plant phase responsive to a known signal equivalent to the control input signal and the

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control system phase such that effectiveness of the cost function parameters, the input weight, and the selectively incorporated predicted future states is determinable.

49. A system for tuning a cost function used by a neural network control system configured to control an operational plant having a known plant phase responsive to each of a range of known signals, the neural network control system including a neural network model and a cost function, the system comprising:

a cost function parameter selector configured to select parameters used in a cost function;

an input weight selector configured to select an input weight to be applied to a control output signal by the cost function;

a predicted future state selector configured to selectively incorporate predicted future states generated by a neural network model;

an iterator configured to iteratively apply a control input signal from a range of known signals;

a cost function calculator configured to calculate a control output in response to the control input signal;

a control system phase determiner configured to determine a control system phase and a control system amplitude of the control output in response to the control input signal; and

a combiner configured to combine a known plant phase responsive to a known signal equivalent to the control input signal and the control system phase such that effectiveness of the cost function parameters, the input weight, and the selectively incorporated predicted future states is determinable.

50. The system of Claim 49, wherein the input weight selector is further configured to iteratively selected the input weight to be applied by the cost function from among a range of input weights.

51. The system of Claim 50, wherein the range of input weights includes a maximum of around 0.001 to a minimum of around 1×10^{-20}.

52. The system of Claim 50, the predicted future state selector is further configured to select a subset of the predicted future states generated by the neural network model.

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53. The system of Claim 52, wherein the predicted future state selector is further configured to select two of the predicted future states generated by the neural network model.

54. The system of Claim 49, wherein the predicted future state selector is further configured to select all of the predicted future states and combine each of the predicted future states with a forget factor such that a proportional weight is accorded each of the predicted future states.

55. The system of Claim 54, wherein the forget factor includes one of a whole and a fractional number raised to an exponent incremented by one for each of the predicted future states.

56. The system of Claim 55, wherein the forget factor is in a range from around 5.0 to around 0.1.

57. The system of Claim 56, further comprising a sequencer configured to sequence the forget factors and the predicted future states such that each of the forget factors is applied to each of the predicted future states.

58. The system of Claim 49, wherein the range of known signals applied by the iterator as the control input signal includes a chirped signal.

59. The system of Claim 49, wherein the cost function includes an expression:

$$C=\sum_{i=1}^{n}\left(G_p \bullet Y_i^2 + G_v \bullet \dot{Y}_i^2 + G_I \bullet I^2\right)$$

where:

C = cost of selected input (I);

i through n represent a range of the predicted future states being evaluated;

G_p = position gain;

Y_i = predicted state of the plant at horizon I;

$\dot{Y}_i$ = predicted rate of change of the state of the plant at horizon I;

G_v = velocity gain; and

G_I = the model input.

60. The system of Claim 49, wherein the cost function parameter selector is further configured to select the position gain and the velocity gain.

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61. The system of Claim 60, wherein the position gain selected by the cost function parameter selector includes one of 0 and 1 and the velocity gain selected by the cost function parameter selector includes one of 0 and 1.

62. The system of Claim 55, wherein the cost function includes an expression:

$$C = \sum_{i=1}^{n} \left(G_p \bullet Y_i^2 + G_v \bullet \dot{Y}_i^2 + G_I \bullet I^2 \right) \bullet W^i$$

where:
C = cost of selected input (I);
i through n represent a range of the predicted future states being evaluated;
G_p = position gain, Y_i = predicted state of the plant at horizon I;
$\dot{Y}_i$ = predicted rate of change of the state of the plant at horizon I;
G_v = Velocity Gain;
G_I = input gain; and
W = the forget factor.

63. The system of Claim 62, wherein the cost function parameter selector is further configured to select the position gain and the velocity gain.

64. The system of Claim 63, wherein the position gain selected by the cost function parameter selector includes one of 0 and 1 and the velocity gain selected by the cost function parameter selector includes one of 0 and 1.

65. The system of Claim 49, wherein a combination of parameters and input weight resulting in three consecutive maximum control output values is dismissed as unstable.

66. The system of Claim 65, wherein the iterator ceases iteratively applying the control input from the range of known signals for the combination of parameters and input weight resulting in three consecutive maximum control output values dismissed as unstable.

67. The system of Claim 49, wherein the control system phase determiner is further configured to determine the control system phase by performing a fast Fourier transform of the control output in response to the control input signal and the known plant phase is determined by performing a fast Fourier transform of the plant phase in response to a plant input.

68. The system of Claim 67, further comprising a stability analyzer configured to identify stable combinations of the cost function parameters, the input weight, and the

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predicted future states wherein a sum of the control system phase and the plant phase ranging between around 150 degrees though 180 degrees to –150 degrees inclusive.

69. The system of Claim 67, wherein more stable combinations of the cost function parameters, the input weight, and the predicted future states are those for which the sum of the control system phase and the plant phase is closest to around 180 degrees or around negative 180 degrees and less stable combinations of the cost function parameters, the input weight, and the predicted future states are those for which the sum of the control system phase and the plant phase is closest to around 0 degrees.

70. The system of Claim 69, further comprising a sorter configured to sort the stable combinations of the cost function parameters, the input weight, and the predicted future states from the more effective combinations to the less effective combinations.

71. A system for tuning a cost function used by a neural network control system configured to control an operational plant having a known plant phase responsive to each of a range of known signals, the neural network control system including a neural network model and a cost function, the system comprising:

a cost function parameter selector configured to select parameters used in a cost function;

an input weight selector configured to select an input weight to be applied to a control output signal by the cost function;

a predicted future state selector configured to selectively incorporate at least two of the predicted future states generated by a neural network model;

an iterator configured to iteratively apply a control input signal from a range of known signals;

a cost function calculator configured to calculate a control output in response to the control input signal;

a control system phase determiner configured to determine a control system phase of the control output in response to the control input signal; and

a combiner configured to combine a known plant phase responsive to a known signal equivalent to the control input signal and the control system phase such that effectiveness of the cost function parameters, the input weight, and the selectively incorporated predicted future states is determinable.

72. A system for tuning a cost function used by a neural network control system configured to control an operational plant having a known plant phase responsive to each of a

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range of known signals, the neural network control system including a neural network model and a cost function, the system comprising:

a cost function parameter selector configured to select parameters used in a cost function;

an input weight selector configured to select an input weight to be applied to a control output signal by the cost function;

a predicted future state selector configured to select each of the predicted future states and combine each of the predicted future states with a forget factor such that a proportional weight is accorded each of the predicted future states;

an iterator configured to iteratively apply a control input signal from a range of known signals;

a cost function calculator configured to calculate a control output in response to the control input signal;

a control system phase determiner configured to determine a control system phase of the control output in response to the control input signal; and

a combiner configured to combine a known plant phase responsive to a known signal equivalent to the control input signal and the control system phase such that effectiveness of the cost function parameters, the input weight, and the selectively incorporated predicted future states is determinable.

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